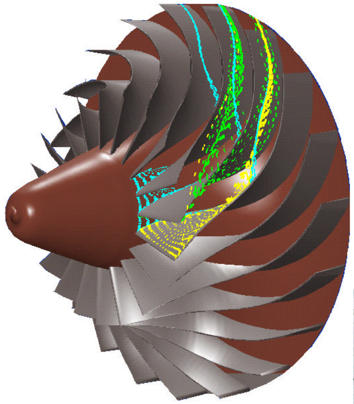
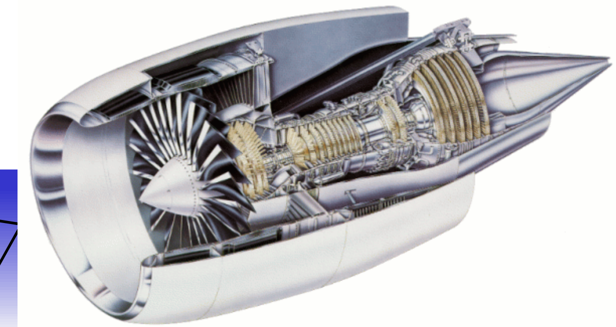
Physics & Process Modeling

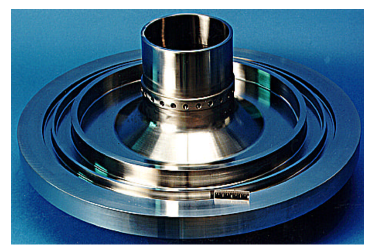




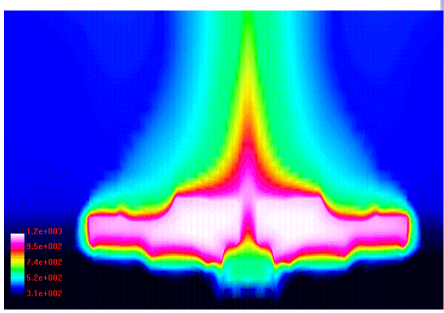
REDUCE COST OF AIR TRAVEL
REDUCE DESIGN CYCLE TIME

DESIGN METHOD IMPROVEMENT

PROCESS MODELING

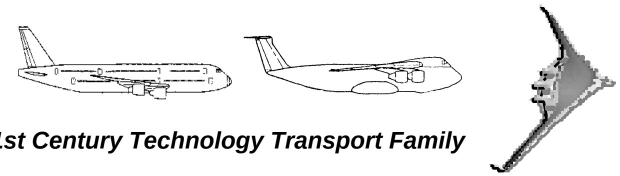


ADVANCED CONCEPTS



PHYSICS-BASED ANALYSIS

Civil Transportation Vision for FACT Application



21st Century Technology Transport Family

Benefits:
- Double capacity within existing infrastructure
- 30% reduction in fuel burn
- 70% reduction in CO_2
- Luxury passenger car interior noise
- No operational noise constraints
- 50% reduction in total airplane operating costs
- 200% increase in revenue pass. miles /gal

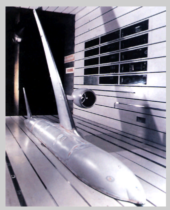
Leapfrog Technology:
- •Advanced Materials
- •Ultra High By-Pass Ratio Eng.
- •Stage 4 -??dB
- •Advanced Configurations
- •Advanced ATM

FACT R&T Base

Barrier Technology Development:

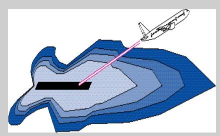
Aerodynamics

W-T tests of advanced aerodynamic concepts



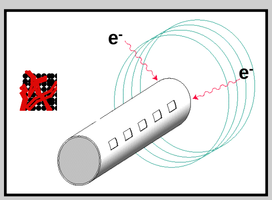
Rn Scaling Issues

Acoustics

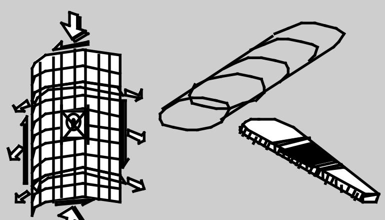


Noise reduction concepts

Materials and Structures



Low Cost Manufacturing



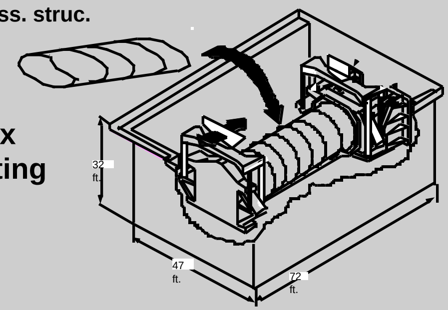
Sub-scale testing & analysis of non-circular structures

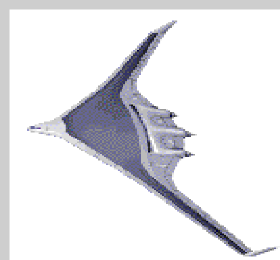
Potential Focused Program Technology Maturation

Scaled Demonstration:

Non-circ. press. struc.

Ground Tests:
- **Large scale, complex combined loads testing**

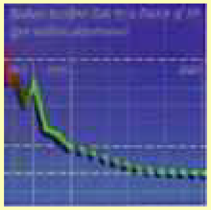




X-Plane:
- **•Thick Airfoils**
- **•Noise Reduction Concepts**
- **•Propulsion/Airframe Integration**

Propulsion R&T Base

Aircraft Morphing Program Sub-Elements



reduce aircraft accident rate

1. **Embedded technologies for airframe monitoring and healing for increased flight safety**

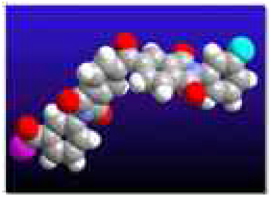
environmental compatibility

2. **Component technologies which enable environmentally compatible integrated self-adaptive airframes**

next-generation design tools

3. **Smart airframe design, integration, and system analysis**

Morphing Technologies



Embedded sensors - embedded fiber optic and micro sensors for damage detection

Specialized polymers - hierarchical polymers with improved properties; analytical techniques for efficient design of polymers

Innovative fabrication - processing structural composites with sensor and actuator integration; embedding smart materials

Piezoelectric materials - high efficiency piezoelectric patch devices, bender actuators, and piezoelectric polymers

Microelectromechanical devices - microactuator devices with higher energy density, force output, and efficiency

Mechatronics - validated models of devices considering actuator and electronics as an integrated system

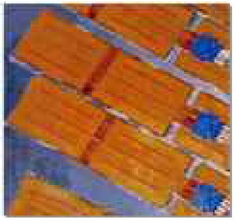
Noise reduction - reduce noise and vibration with minimum weight and space penalties; adaptive inlet shaping to reduce noise

Shape memory alloy hybrid composite - fabrication technology for aerospace structures exposed to large sonic loads

Embedded interdigitated electrode piezoelectric fiber composites - for improving aeroelastic performance of aerospace structures

Active and shunted piezoelectric - patches for aeroelastic control

Multi-degree of freedom models - multifunctional structures with surface-bonded or embedded piezoelectric patches



Aeroelastic control - seamless control surfaces, wing twist, extendible leading edge control surfaces, variable stiffness

Innovative flow control - separation control, generation of control forces, reduction in cavity noise, viscous drag reduction

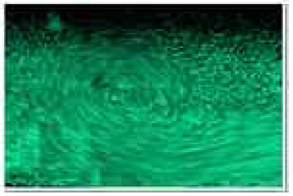
MEMS flow sensor technology - detect flow separation and transition to turbulence; integrated sensor arrays for flight test

Optimal control theory - CFD for active flow control to determine actuator response, actuator and sensor location, required sensor

Real-time system identification - feedback and feedforward control

Discrete and continuous optimization - for sensor/actuator location

Device MDO - improve effectiveness, weight or power requirements of smart devices



General Aviation Propulsion Program

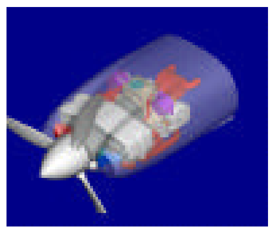
ASTT

PROGRAM GOAL: By 2000,
Develop and flight-demonstrate affordable revolutionary propulsion systems for general aviation aircraft to stimulate revitalization of the U.S. General Aviation Light Aircraft Industry

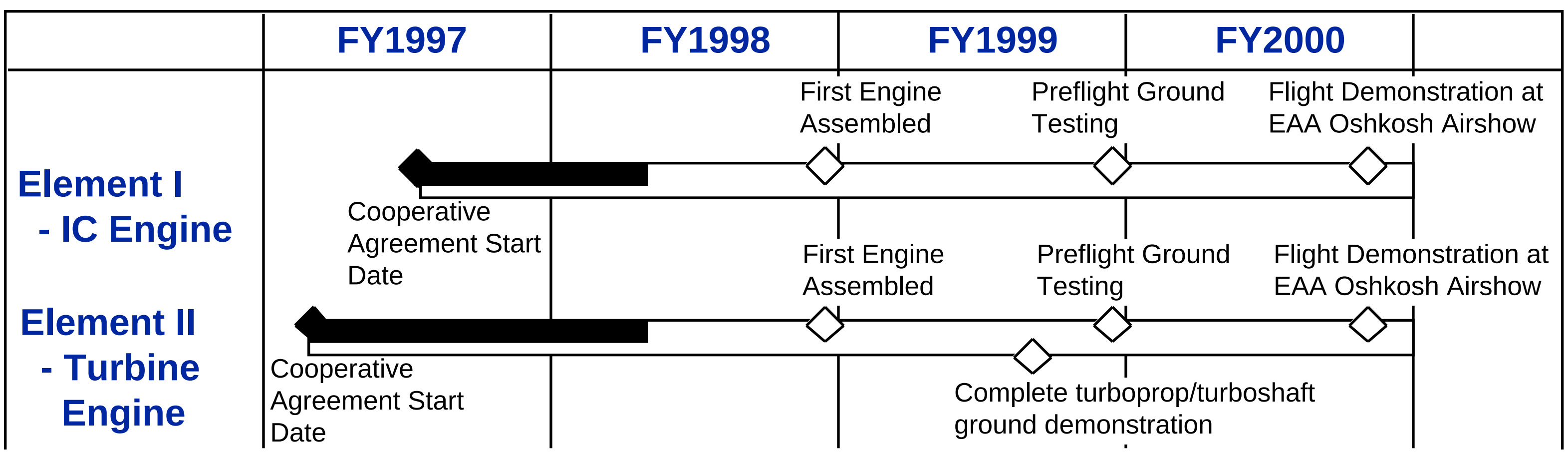
ENGINE DESIGN OBJECTIVES:	IC	Turbine
Cost Reduction	50%	90%
Fuel	JP	
Time Between Overhaul Increase	75%	50%
Specific Fuel Consumption Increase	25%	
Environmental Compliance (Noise & Emissions)	Meet/exceed expected Standards for year 2000	

Implemented Through Cooperative Agreements

IC: Teledyne Continental Motors
- 200 hp, 2 Stroke, Diesel, JP Fuel
- Airframe Partners
  - Cirrus
  - Lancair
  - New Piper



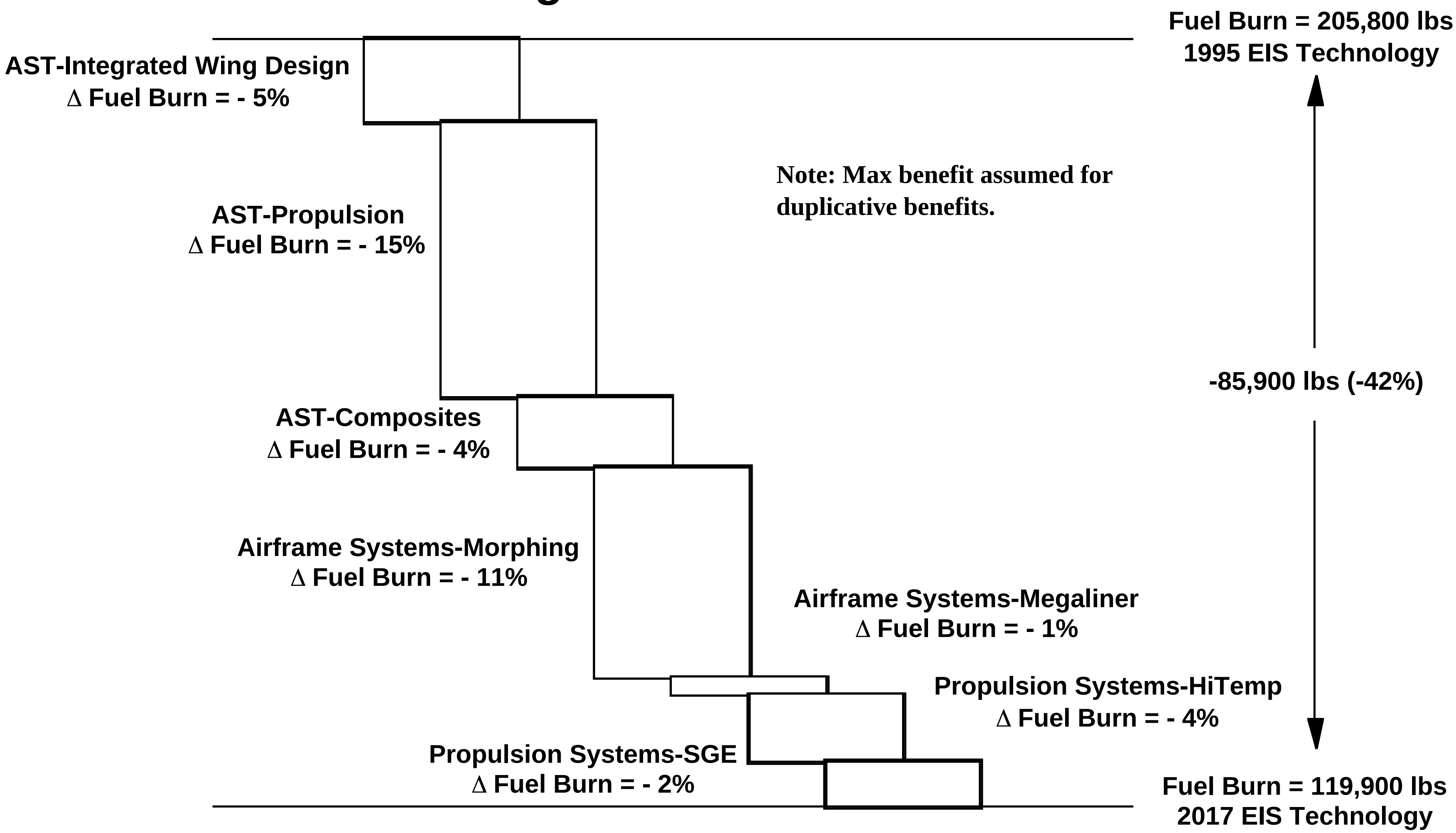
Turbine: Williams International
- 700 lb Thrust High Bypass Turbofan
- Airframe Partners
  - Cessna • Lancair
  - Cirrus • New Piper
  - Raytheon
  - VisionAire



LONG HAUL/MEDIUM CAPACITY CONVENTIONAL SUBSONIC TRANSPORT

2-Engine, 325 Passengers, 6500 nmi Design Range, 10000 ft Field Length

AST & Base Program Fuel Burn "Waterfall"

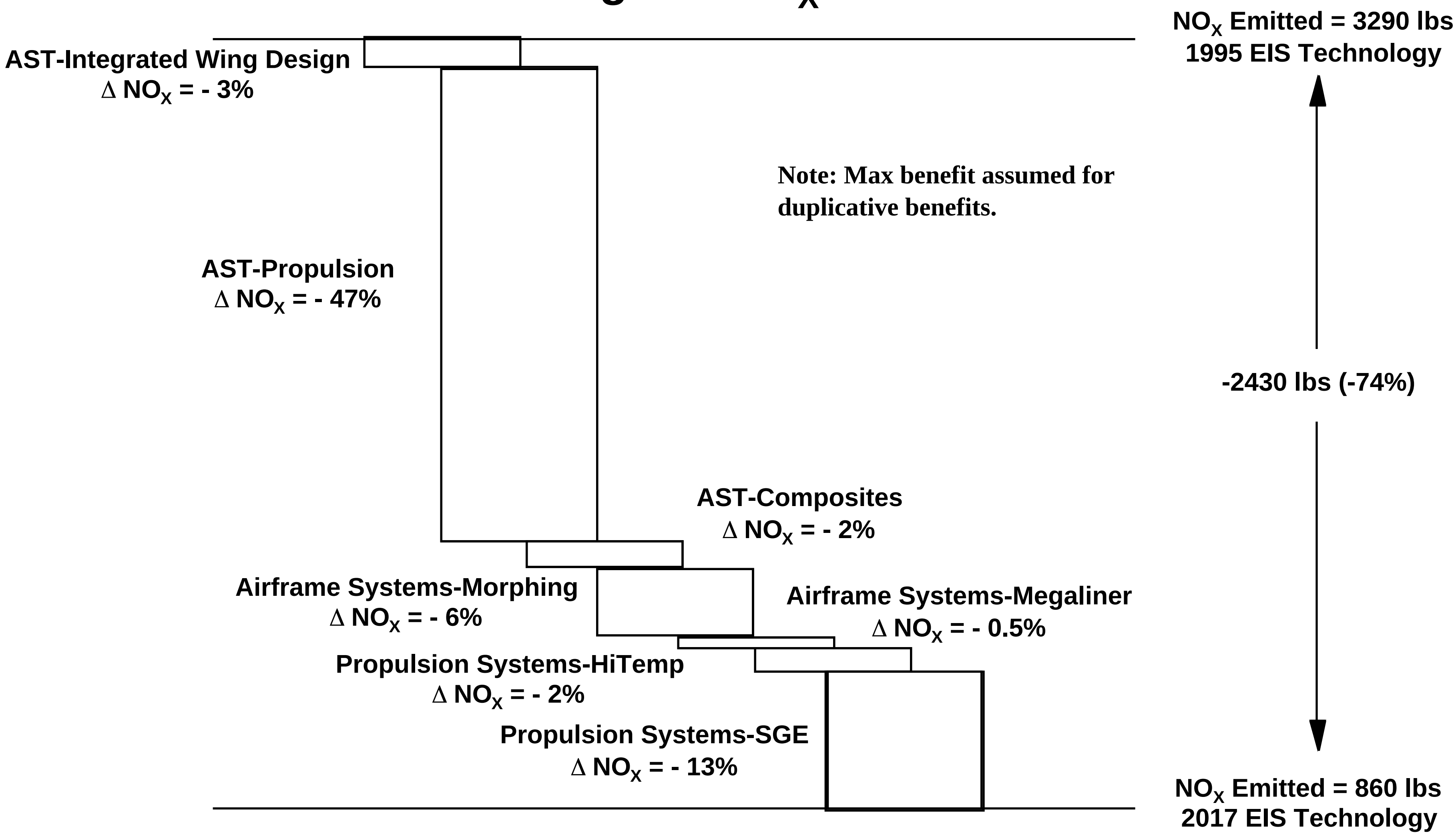


NASA Inter-Center Systems Analysis Team

LONG HAUL/MEDIUM CAPACITY CONVENTIONAL SUBSONIC TRANSPORT

2-Engine, 325 Passengers, 6500 nmi Design Range, 10000 ft Field Length

AST & Base Program NO_X "Waterfall"



NASA Inter-Center Systems Analysis Team

2007 - Technology Challenges for JP-Type Fueled Aircraft with reductions of 25 % in CO2 and 67 % in NOx

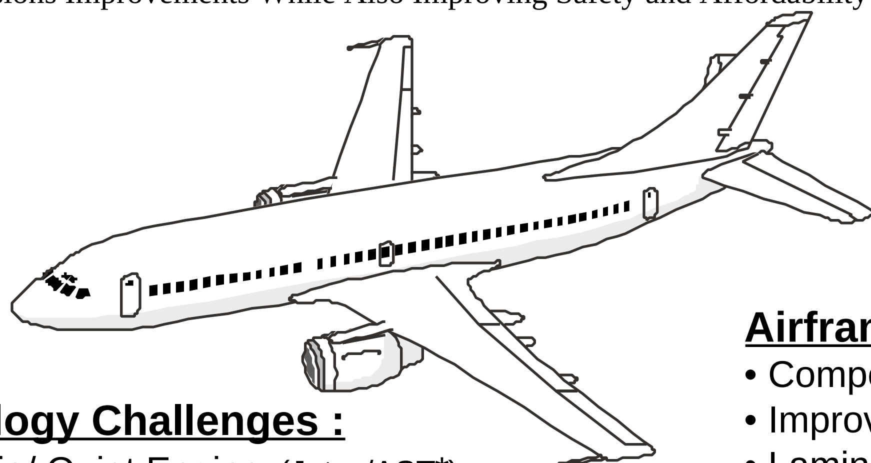
Technical Objectives

➤ Reduce CO_2 Emissions from Future Aircraft by 25 % in 10 years.

➤ Reduce NOx Emissions from Future Aircraft by 67 % in 10 years.

➤ Address New Emission Concerns by Characterize Emission Levels of Aerosols, Particulates, and Other Minor Trace Species to their Lowest Practical Limits.

➤ Enable These Emissions Improvements While Also Improving Safety and Affordability of Operations



Propulsion Technology Challenges :

- Ultra High Bypass Ratio/ Quiet Engine (Jnt.w/AST*)
    - Light Weight, High Temp. Mat'l. & Struct. (Jnt.w/AST)
    - Non-Traditional Prop/Airframe Integ.
    - Intelligent Controls/ MEMS
- Combustion
    - Improved injectors and liners
      - 70% NO_x reduction (Jnt.w/AST)
    - Characterize Other Emissions (Jnt.w/AST, Base R&T & HSR)

* Joint with AST, Base R&T, or HSR

Airframe Technology Challenges:

- Composite Wing (Jnt.w/AST)
- Improved Aerodynamics (Jnt.w/AST)
- Laminar Flow Control
- Monolithic Structures

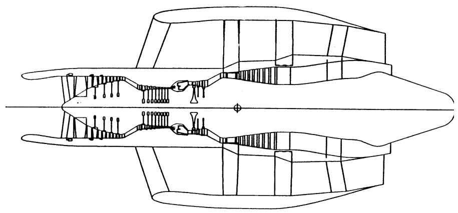
Operations, Modeling, & Assessment:

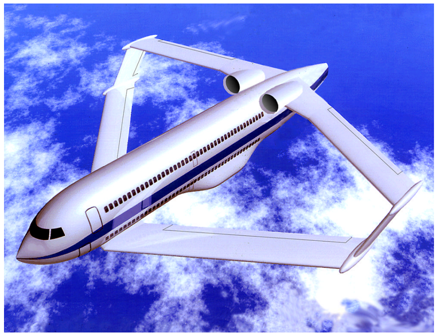
- Improved Ground Operations
- Improved Flight Operations
- Improved Modeling and Assessments (Jnt.w/AST)

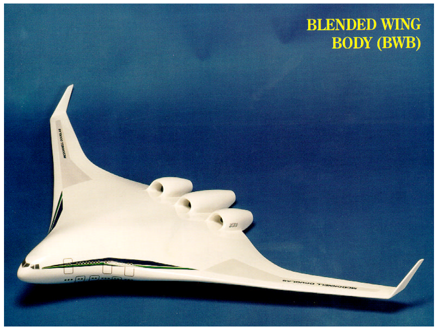
2022 - Technology Challenges for Carbon-Based Fueled Aircraft with reductions of 50 % in CO2, 80 % in NOx, and in other emissions

Technical Objectives

- ➤ Reduce CO_2 Emissions from Future Aircraft by 50 % in 25 years.
- ➤ Reduce NOx Emissions from Future Aircraft by 80 % in 25 years.
- ➤ Address New Emission Concerns by Reducing Emission Levels of Aerosols, Particulates, and Other Minor Trace Species to their Lowest Practical Limits.
- ➤ Enable These Emissions Improvements While Also Improving Safety and Affordability of Operations







Propulsion Technology Challenges :

- Proof-of-Concept Tests of Revolutionary Carbon-Based Fueled Propulsion System
  - Smart Adaptive Engine (MEMS, Aspirative)
  - New Cycles/ Adv. Methane Cooled Engine
- Proof-of-Concept Tests of Revolutionary Carbon-Based Fueled Combustion System
  - Multi-Staged & Variable Geom.- 80% NO_x reduction
  - Reduce Other Emissions
- Alternate Fuels (Low C/H Ratio/Methane & Low Sulfur Fuels)

Airframe Technology Challenges:

- Proof-of-Concept Tests of Revolutionary Carbon-Based Fueled Airframe Systems
  - Slatless/Flapless Airfoils
  - Active Piezoelectrics
  - Fluidic Thrust Vectoring
  - Box vs. Strut vs. Blended Wing
  - Opto-Electronics
  - Designer Materials/Structures

Operations, Modeling, & Assessment:

- Revolutionary Ground Operations
- Revolutionary Flight Operations
- Improved Assessments